AD-A072 006 FEDERAL AVIATION ADMINISTRATION WASHINGTON DC OFFICE --ETC F/G 6/16

INTERSTIMULUS INTERVAL AS IT AFFECTS TEMPORARY THRESHOLD SHIFT --ETC(U)

JUN 79 J V TOBIAS

UNCLASSIFIED FAA-AM-79-16 NL

| OF |

AD A072006

END

DATE FILMED

8 --79

DDC

OF 1

72006

1.0 2.8 2.5 3.2 2.2 3.6 4.0 2.0 1.1 1.8 1.25 1.4 1.6

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A

FAA-AM-79-16

INTERSTIM

ADA072006

DDC FILE COPY

Do

FAA-AM-79-16

INTERSTIMULUS INTERVAL AS IT AFFECTS TEMPORARY THRESHOLD SHIFT IN SERIAL PRESENTATIONS OF LOUD TONES

Jerry V. Tobias
Civil Aeromedical Institute
Federal Aviation Administration
Oklahoma City, Oklahoma

DEPARTMENT OF TRANSPORTATION ★ UNITED STATES OF AMERICA ★

June 1979

Document is avialable to the public through the
National Technical Information Service,
Springfield, Virginia 22161

Prepared for
U.S. DEPARTMENT OF TRANSPORTATION
Federal Aviation Administration
Office of Aviation Medicine
Washington, D.C. 20591

NOTICE

Technical Report Documentation Page

1. Report No.	2. Government Accession No.	3. Recipient's Catalog No.
FAA-AM-79-16		

4. Title and Subtitle
INTERSTIMULUS INTERVAL AS IT AFFECTS TEMPORARY THRESHOLD SHIFT IN SERIAL PRESENTATIONS OF LOUD TONES

5. Report Date
JUNE 1979

6. Performing Organization Code

7. Author(s)
JERRY V. TOBIAS

8. Performing Organization Report No.

9. Performing Organization Name and Address
FAA CIVIL AEROMEDICAL INSTITUTE
P.O. BOX 25082
OKLAHOMA CITY, OKLAHOMA 73125

10. Work Unit No. (TRAIS)

11. Contract or Grant No.

12. Sponsoring Agency Name and Address
OFFICE OF AVIATION MEDICINE
FEDERAL AVIATION ADMINISTRATION
800 INDEPENDENCE AVENUE, S.W.
WASHINGTON, D. C. 20591

13. Type of Report and Period Covered

14. Sponsoring Agency Code

15. Supplementary Notes
Work was performed under Task AM-E-79-PSY-71.

16. Abstract
Temporary threshold shifts were measured repeatedly during a session in order to determine effects of interstimulus interval (ISI) on the shift. The fatiguing sound was a 3-minute, 110-dB-SPL, 4,000-Hz tone. Immediately following the 3-minute stimulation, Békésy-audiometric tracings were made for 3 minutes at 5,656 Hz. Then the subject sat quietly for the ISI that was used during that session. The effect of the subject's rest time or time off was compared at two points on the recovery curve: at 30 seconds and at 2 minutes following the cessation of the fatiguing sound. For susceptible subjects tested with short-duration ISIs, each successive threshold showed a greater shift than the earlier ones for at least four tests. As ISI was increased, improvement seemed not to follow the expected linear form. At some critical value that varies from subject to subject, successive tests no longer differ from each other; each one is similar to a first trial in which no previous exposure to the high-level tone has occurred. For most subjects run under these conditions, the critical ISI value is at least 30 minutes.

17. Key Words	18. Distribution Statement
Auditory Threshold Temporary Threshold Shift Noise	Document is available to the public through the National Technical Information Service, Springfield, Virginia 22161

19. Security Classif. (of this report)	20. Security Classif. (of this page)	21. No. of Pages	22. Price
Unclassified	Unclassified	8	

Form DOT F 1700.7 (8-72) Reproduction of completed page authorized

A 264 320

INTERSTIMULUS INTERVAL AS IT AFFECTS TEMPORARY THRESHOLD SHIFT IN SERIAL PRESENTATIONS OF LOUD TONES

Although the value of measurements of temporary threshold shift (TTS) as a predictor of susceptibility to permanent, noise-induced hearing loss is being questioned today (2), nevertheless, TTS studies are valuable in describing the condition of the cochlea following noise exposures. They permit one to draw useful conclusions about the presence of waste products in the inner ear fluids and about the efficient or inefficient flushing away of toxic products from the region around the hair cells. They permit one to chart the course of recovery of the end organ following a change that lasts a minute or an hour or a day. And it is not certain that they do not have some predictive value regarding susceptibility to noise-induced hearing loss.

One problem with studies in which the measuring tool is TTS is that the experimenter is commonly limited to one or two trials per day of testing because sufficient recovery time is required to insure that the first noise exposure and test have no important influence on succeeding exposures and tests. However, I have found no published experiments that were designed to determine a "safe" interstimulus interval (ISI)--that is, a duration between exposures that is long enough to keep any residual cochlear problem resulting from an early stimulation from affecting the tests one makes after a later stimulation. Of course the problems of conducting an exhaustive study of the question are huge. To collect enough data to deal with the whole family of possible responses would require years and years of work with a large population of ears. The product would be a matrix that included a wide range of signal levels, frequencies, complexities, and durations, and for each of the signals, one would have to test changes in threshold shift as a function of the duration of pauses interspersed between tests in a long series. For such a study to be completely valuable, it ought to include not only normal ears, but several kinds of pathological ears as well.

In conjunction with another project (one in which TTS was being used as a measure of interactive effects on hearing of loud sounds and certain over-the-counter drugs), one cell of that complex matrix was studied. This report, then, furnishes preliminary results in the larger problem of determining the range of effects of ISI on serial measurements of TTS.

Method and Procedure. The fatiguing signal was a 3-minute, 110-dB-SPL, 4,000-Hz tone. As is common in TTS measurements for such high-level tones, the 4,000-Hz stimulating frequency was expected to have its maximum shifting effect one-half octave higher (1)--at 5,656 Hz--and so that higher frequency was the one at which the threshold-shift tests were performed. The test equipment is shown in Figure 1. Two Hewlett-Packard 201CR oscillators were used, one for the 4,000-Hz tone and one for the 5,656-Hz tone, and were selected by a

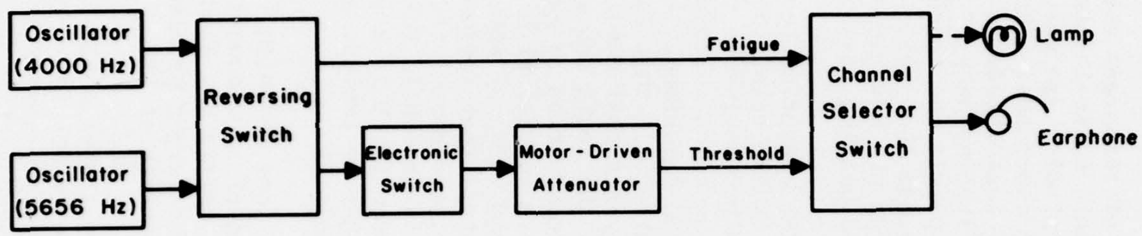

Figure 1. Block diagram showing the major components of the fatiguing and testing systems used.

reversing switch that determined which of two channels each tone was used in. One channel that included an electronic switch (Grason-Stadler 829) and a motor-driven attenuator (Grason-Stadler E3262A) was used to measure thresholds, both before and after tonal stimulation. The attenuator was adjusted to provide a 4-dB/second level change. The electronic switch provided a pulsed tone with a 10-millisecond rise time, a 250-millisecond on time, and a 50-percent duty cycle in order to maximize the subject's certainty that he was listening to the right tone (rather than to any head noises) and to minimize any perstimulatory fatigue. The other channel was used to provide the fatiguing tone. Sounds from either channel were selectively directed through a TDH-39 earphone to the subject's right ear (except in one instance in which a subject was found to have a mild hearing loss in the right ear; that person was tested on the left).

Subjects were nine young adult men and women with no history of hearing problems. A short case history was taken before subjects were accepted for use in the experiment, as was a pure-tone, air-conduction audiogram. Every tested ear fell well within the normal range across all audiometric frequencies. Next, subjects were taught to take their own thresholds with the Békésy-type motor-driven attenuator that would be used in the experiment and were tested on pulsed tones at 4,000 Hz and at 5,656 Hz. The first loud-tone exposure, like each succeeding one, was a continuous, 3-minute presentation of a 110-dB-SPL, 4,000-Hz tone.

During the 3-minute presentation of the fatiguing tone, a light was turned on in the sound booth. Subjects were instructed to begin threshold testing the moment that the light went out. At that instant, the 4,000-Hz continuous tone was switched off and the pulsing 5,656-Hz tone was switched on at a level that was 30 dB above that day's threshold for that frequency. The 30-dB rise was selected to approximate threshold shifts that had been measured on other subjects during a pilot study. Although the recovery curves varied somewhat from subject to subject and from day to day, the 30-dB choice proved to be adequate. After a 3-minute test, all sound was turned off for a period of time--5 minutes, 10 minutes, 15 minutes, 20 minutes, 30 minutes, or 45 minutes--and then the 3-minute, 4,000-Hz fatiguing tone was turned on again. During a given day, these ISIs were always the same; that is, a subject might receive a 3-minute loud tone followed by a 3-minute test, a 5-minute (or one of the other durations) pause, another 3-minute loud tone, another 3-minute test, another 5-minute pause, and so on for six cycles (except in the case of the 45-minute silent period, for which only five cycles were completed because of the overly long total time that that would have kept the listener in isolation).

Results and Discussion. Recovery curves were plotted from the Békésy tracings by inserting a smoothed curve along the midpoint of the response lines that represent the amount of change in attenuation. Comparisons between conditions were made at two points on the recovery curve: at 30 seconds (TTS_{30}) after the cessation of the 4,000-Hz fatiguing tone and at 2 minutes (TTS_{120}) following the cessation of the tone.

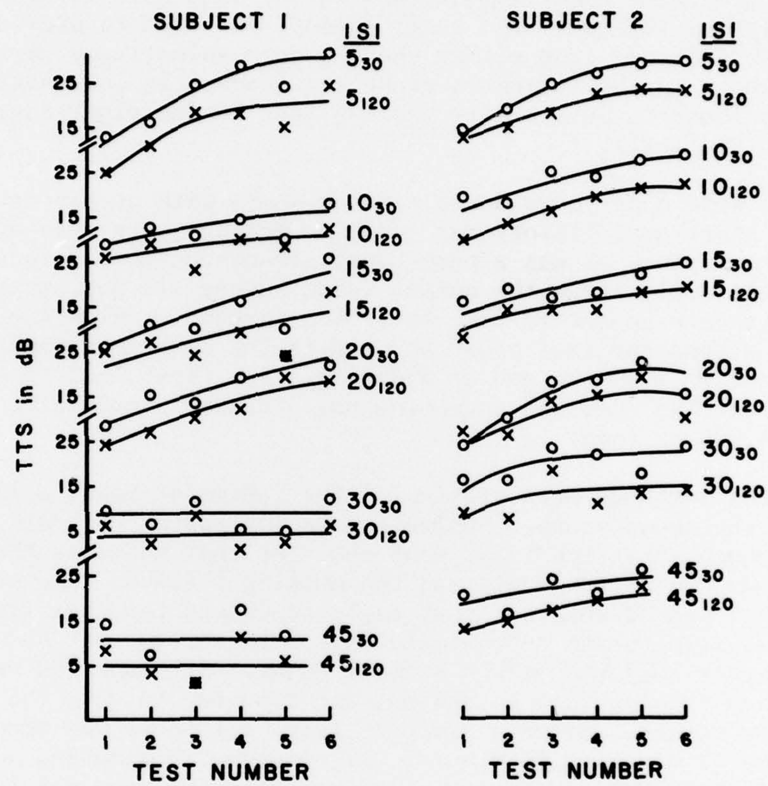

Figure 2. Patterns of recovery for two TTS-susceptible subjects. Each curve represents the successive amounts of TTS measured on that subject for a series of tests separated by the ISI shown beside that curve. Note that the two subjects' patterns differ from each other.

One expectation in such experiments is that the threshold shift is larger and less stable at the 30-second point than at the 2-minute point, and these data confirm that idea. Another expectation is that, for short ISIs, at least, each successive threshold in a series will be at a higher level than the *preceding one*--up to some ultimate value of TTS. For no subject tested is it possible to confirm that such an ultimate value of TTS was reached, but most subjects certainly demonstrated the increasing TTS with successive tests during a session. However, some subjects showed very little shift at TTS_{30} and no measurable shift at TTS_{120} following the loud tones that were used here; presumably, the levels or durations that would affect them significantly had not been reached. Figure 2 shows the results for two of the subjects who did react to the fatiguing tone. These curves show the increased TTS with each succeeding test (at least for the first four); the parameter is ISI. Note that, for ISIs of 5, 10, 15, and 20 minutes (or, because 3 minutes of each cycle is taken up with listening to threshold-level signals, one might consider these to be "rest times" of 8, 13, 18, and 23 minutes), both of these subjects, like most of the others, show an essentially monotonic increase in TTS (the few visible reversals are smaller than the expected variability of the measurement). At an ISI of 30 minutes and even more at 45 (or 33 and 48 minutes, including the 3 minutes of threshold testing), the new increment of TTS following each new exposure to the loud sound is doubtful. For the 3-minute, 110-dB-SPL tone, a 45-minute ISI can be considered adequate for full recovery.

The critical value of ISI--the duration of quiet through which the subject must pass before the experimenter can be fairly confident that the next test will not be influenced by the last--clearly differs from subject to subject. But once that value is exceeded, successive tests no longer differ from one another; each one is similar to the first trial in which no previous noise exposure has occurred.

From the data collected in this study of a few subjects exposed to a small part of the full matrix of fatiguing signals that ought to be investigated, no general statements can safely be made. Still, some unsafe but potentially interesting ideas are worth comment. The ideas are only derivable from study of individual curves (because subjects vary so much from each other) and from some guesses that can be made on the basis of the shapes of composite curves (Figure 3) of mean scores for all subjects (but note that slopes are greatly decreased--almost to the point of homogeneity--in the composite curves). Remember that all these statements need to be prefaced with "maybe." People exposed to loud sounds are likely affected by the total energy in the sounds (see Ward, 1979, for a discussion of the current status of this "equal energy hypothesis"); a linear trade between time and intensity therefore is expected, and a given effect can be maintained by, for example, doubling the duration while halving the amplitude. Is ISI similarly a linear function of time? That is, if one doubles the ISI's duration, ought one to expect a halving of the TTS? These data suggest not. Despite its *shortcomings*, Figure 3 indicates that a change in ISI from 10 minutes up to nearly 30 has no real influence on the results. Then something happens when

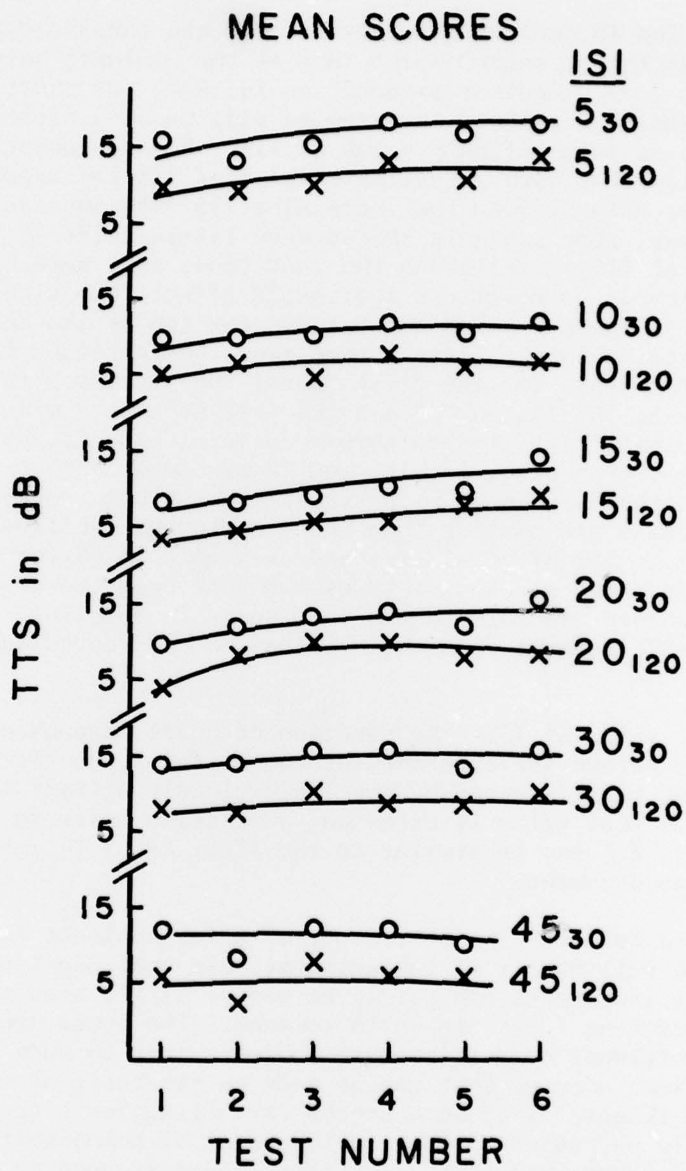

Figure 3. Average patterns of recovery for all tested subjects. The relative flatness of the curves and their apparent similarity of form is attributable to those subjects who were minimally susceptible to the amount and duration of loud tone that was used and to the intersubject variability that tends to wash out some of the larger differences that can be seen in individual curves.

the ISI is increased a bit more. Perhaps, if this effect is real, it means that a critical period of half an hour or so is required for the poor vascular system in the inner ear to flush out most of the noise-created byproducts of end-organ stimulation. Such an outcome might partially account for the relatively good recovery from industrial noise that many workers make overnight, apparently even when they work overtime and thus receive industrial-noise exposures that far exceed the usual 8 hours.

Certainly much more of the ISI matrix needs to be filled with data. Of course this explanation is not intended to deal with the slow, asymptotic recoveries of the last few decibels of TTS that are seen for high-level, long-duration noise exposures, or with the unusual recovery patterns reported (3) for exposures that permit no quiet time in which the ears can rest during 24-hour and longer periods.

References

1. Epstein, A., and E. D. Schubert: Reversible Auditory Fatigue Resulting from Exposure to a Pure Tone. AMA ARCHIVES OF OTOLARYNGOLOGY, 65:174-182, 1957.

2. Humes, L. E.: Susceptibility to TTS: A Review of Recent Developments. In J. V. Tobias, W. D. Ward, and G. Jansen (Eds.), Proceedings of the Third International Congress on Noise as a Public Health Problem. American Speech-Language-Hearing Association, Washington, D.C., 1979 (in press).

3. Nixon, C. W., D. L. Johnson, and M. R. Stephenson: Asymptotic Behavior of Temporary Threshold Shift and Recovery from 24- and 48-Hour Noise Exposures. AVIATION, SPACE, AND ENVIRONMENTAL MEDICINE, 48:311-315, 1977.

4. Ward, W. D.: Noise-Induced Hearing Loss: Research Since 1975. In J. V. Tobias, W. D. Ward, and G. Jansen (Eds.), Proceedings of the Third International Congress on Noise as a Public Health Problem. American Speech-Language-Hearing Association, Washington, D.C., 1979 (in press).